

the surface water. The result is that the warm surface water in the center of the anticyclonic whirl, the Sargasso Sea, is there drawn downward until it reaches even the greatest depths of the Atlantic.

In the central region of the Skagerrack one always finds the cold bottom water at a very slight depth. Although the surface water is relatively warm in summer and fall, one meets, at depths of 5 or 10 meters, with water having a temperature but a few degrees above 0°C. Along the shores of the Skagerrack, on the other hand, this cold water is not met with until considerable depths have been attained. It thus appears that there is a bulging up of the cold water in the Skagerrack. Now, it is known that the surface water of the Skagerrack has a pronounced cyclonic circulation, since there are two currents, one of which comes from the North Sea, hugging the Danish coast, the other flows from the Baltic following the southern coast of Norway. The cyclonic movement of the surface water, thus produced, signifies an intensified centrifugal force of the same whereby the water of the lower strata in the center of the Skagerrack is drawn upward.

It would be easy to multiply such examples, but I shall leave that to those readers of this essay who are interested in the methods I have described. They are easy to adopt and afford very simple explanations of a large number of meteorological and hydrographical phenomena.

551.3 (74.7-22)

DAILY MARCH OF THE METEOROLOGICAL ELEMENTS IN THE PANAMA CANAL ZONE.¹

By Hofrat Prof. Dr. JULIUS VON HANN.

[Presented to the Imperial Academy of Sciences, Vienna, Mar. 26, 1914.]

For a number of years I have received regularly from the Chief Engineer at Culebra, Canal Zone, and at the suggestion of Prof. Cleveland Abbe, of Washington, D. C., a manuscript copy of the bihourly readings of the meteorological elements (pressure, temperature, and relative humidity) for the stations in the Canal Zone. I felt to a certain extent honor bound not to permit these valuable copies, which are sent to a very limited number of persons, to lie unused, and therefore propose to communicate the results of my computations. I have taken the mean hourly pressures for four or five years at Alhajuela, on the Rio Chagres about 10 kilometers above Gamboa, from an existing publication.² The stations and their geographical coordinates are given in the following table:³

¹ The present important paper is a translation of the following:
Hann, J. v. Der tägliche Gang der meteorologischen Elemente am Panamakanal. (Vorgelegt in der Sitzung am 26. März 1914.) Aus den Sitzungsber. d. Kaiserl. Akad. d. Wiss. in Wien, Math.-naturw. Kl., Jänner 1914, 123: 171-204. Wien, 1914. 34 p. 8°.
² Abbot, H. L. Hourly climatic records on the Isthmus of Panama. MONTHLY WEATHER REVIEW, Washington, June, 1904, 32: 267-272.

³ Prof. Hann adopted the following coordinates and altitudes for his work:
Ancon, latitude, 8° 57' north; longitude, 79° 31' west; altitude, 28 meters.
Culebra, latitude, 9° 02' north; longitude, 79° 40' west; altitude, 123 meters.
Alhajuela, latitude, 9° 12' north; longitude, 79° 37' west; altitude, 44 meters.
Colon or Cristobal, latitude 9° 22' north; longitude, 79° 55' west; altitude, 10 meters.

But he states explicitly that these are only approximate, since they were not given in the publications available to him, and he had to estimate them from a very small sketch map in the Proceedings of the American Society of Civil Engineers, New York, January, 1913, 39, no. 1. There is no serious discrepancy between the two sets of figures. Culebra meteorological station was discontinued September 12, 1914. Ancon station was moved to the near-by Balboa Heights, altitude of barometer circuit 118 feet, October 1, 1914.—[C. A., Jr.]

Meteorological station.	Aspect.	North latitude.	West longitude.	Altitude. (M. S. L.)
Ancon (Panama).....	Pacific coast.....	8 57.6	79 33	Feet. 86.4
Alhajuela.....	Inland.....	9 12.3	79 37	140
Colon.....	Atlantic coast.....	9 22	79 54.5	4
Cristobal (dock).....	do.....	9 21.1	79 55.5	(?)
Culebra.....	Pacific inland.....	9 03	79 39.3	384

This table is based on data furnished October 27, 1914, in a letter from George W. Goethals, Governor of the Panama Canal. A sailing chart of the Canal⁴ is now available.

The mean pressures are not corrected for gravity, but they are reduced to sea level. The barometer correction is also given for Alhajuela and was used by me in calculating the mean. The other barometer readings are probably also corrected since the yearly means agree with those for Alhajuela; but the monthly means for the latter station are not in good agreement with those for the other stations. This is probably due to the fact that the means are for other series of years (1900-1904, in part for 1899-1903; while my stations are for 1907-1912 or 1908-1913, with a few gaps). In order to better judge of the causes underlying the monthly differences in the daily march of the meteorological elements, it will be well to consider first the monthly means of the meteorological elements before discussing their daily march. The conditions of wind and rain are particularly important.

MONTHLY MARCH OF THE ELEMENTS.

The highest mean temperature and maximum atmospheric dryness occur in March and April; the lowest temperature occurs in November.

From May to December, inclusive, the atmospheric humidity is uniformly high. January to April, inclusive, are dry. Colon on the Atlantic coast is considerably the moister.

Rainfall increases from the Pacific litoral to the Atlantic coast (Ancon has 181 centimeters, Colon 318 centimeters). From January to March, inclusive, it is very dry; during these three months Ancon receives but 3.7 per cent, Culebra but 3.3 per cent, and Colon 5.5 per cent of the respective annual rainfalls. April is the transition period to the rainy season, with 4 per cent, 3.4 per cent, and 3.2 per cent, respectively. On the Pacific slope the principal rainy months are May and October and November. On the Atlantic coast at Colon the rainiest months are July and October. In the case of Alhajuela I have also computed the average rainfall and the number of rain days for the period to which the daily pressure march corresponds.

⁴ Isthmian Canal Commission. "Chart of the Panama Canal, 1904-1914. Scale 1:40,000. Latitudes and longitudes are based on the Panama-Colon datum adopted in 1911. [U. S. Hydrographic Office.] This chart is issued in two sheets, and is intended to serve for the navigation only of the canal; it gives no reliable topographic information beyond general outlines and does not extend to Alhajuela.—[C. A., Jr.]

TABLE 1.—Monthly averages of pressure and temperature in the Panama Canal Zone.

Months.	Sea-level pressures.				Temperatures (true means).			
	Ancon.	Culebra.	Alhajuela.	Colon.	Ancon.	Culebra.	Alhajuela.	Colon.
	Mm.	Mm.	Mm.	Mm.	°C.	°C.	°C.	°C.
January.....	757.7	757.8	757.8	758.6	25.7	24.6	26.0	26.3
February.....	58.1	58.3	57.8	59.1	25.9	24.8	27.0	26.2
March.....	57.9	58.1	57.7	59.0	26.4	25.3	27.2	26.6
April.....	57.6	57.7	57.3	58.5	26.6	25.7	27.3	26.6
May.....	57.5	57.7	57.6	58.1	25.9	25.3	26.1	26.4
June.....	57.6	57.7	57.4	58.0	25.8	25.2	26.5	26.2
July.....	757.6	757.7	757.7	758.2	25.8	25.1	26.2	26.2
August.....	57.4	57.6	57.7	57.8	25.8	25.0	26.5	26.2
September.....	57.1	57.4	58.0	57.6	25.8	24.9	26.4	26.1
October.....	57.3	57.6	58.1	57.7	25.2	24.5	26.0	25.6
November.....	57.1	57.3	57.9	57.5	24.9	24.2	25.9	25.7
December.....	57.0	57.2	57.6	57.9	25.5	24.6	26.1	26.1
Year.....	757.5	757.7	757.7	758.2	25.8	24.9	26.4	26.2

TABLE 2.—Monthly averages of atmospheric moisture in the Panama Canal Zone.

Months.	Relative humidity.			Vapor pressure.		
	Ancon.	Culebra.	Colon.	Ancon.	Culebra.	Colon.
				Mm.	Mm.	Mm.
January.....	77	79	80	13.0	13.2	30.3
February.....	75	78	80	18.6	18.0	20.2
March.....	78	74	77	18.6	17.8	20.0
April.....	77	78	80	20.0	19.0	20.7
May.....	85	85	85	21.1	19.2	21.7
June.....	86	88	87	21.2	21.0	22.0
July.....	86	87	87	21.2	20.7	22.0
August.....	86	88	87	21.7	20.7	22.0
September.....	87	88	87	21.6	20.4	22.0
October.....	87	89	88	20.8	20.5	20.2
November.....	88	89	88	20.0	20.1	21.4
December.....	83	85	85	23.1	19.5	21.3
Year.....	82	84	84	20.2	19.6	21.1

TABLE 3.—Percentage frequency of the eight wind directions in the Panama Canal Zone.

Wind directions.	Dry season.			Rainy season.			Year		
	Naos.	Gamboa.	Colon.	Naos.	Gamboa.	Colon.	Naos.	Gamboa.	Colon.
North.....	39	43	51	24	18	10	31	24	32
Northeast.....	9	10	46	5	10	0	7	15	17
East.....	3	3	0	7	3	10	5	4	4
Southeast.....	5	0	0	10	7	8	6	3	4
South.....	1	1	0	16	10	32	6	6	16
Southwest.....	0	1	0	7	10	10	5	5	6
West.....	3	14	0	13	9	13	5	5	7
Northwest.....	40	14	0	19	11	12	29	16	9
Calm.....	0	28	1	0	25	7	1	27	6
Northerly.....	88	67	97	48	39	22	67	55	58
Southerly.....	6	1	1	32	24	50	14	9	26

In this table Naos, on the Pacific coast, represents Ancon, Gamboa represents Culebra. I have no wind records for Ancon and Culebra.

TABLE 4.—Monthly average rainfalls in the Panama Canal Zone.

Month.	Ancon (16 yrs.).	Culebra (22 yrs.).	Alhajuela (14 yrs.).	Colon (42 yrs.).	Alhajuela.*	Ancon.	Culebra.	Colon.
	Mm.	Mm.	Mm.	Mm.	Mm.	Days.	Perct.	Perct.
January.....	26	44	31	101	33	7.2	1.4	1.8
February.....	22	14	20	57	4	2.0	1.2	0.7
March.....	30	17	17	48	16	3.0	1.1	0.8
April.....	70	97	82	104	100	8.6	4.9	4.4
May.....	227	284	324	315	287	21.7	12.4	12.8
June.....	207	225	327	339	262	24.2	11.5	10.0
July.....	207	242	338	416	365	23.8	11.6	10.7
August.....	191	267	332	381	324	23.0	10.6	10.8
September.....	189	235	295	318	306	19.6	10.4	12.6
October.....	278	293	343	363	377	23.2	15.3	13.0
November.....	265	312	282	555	410	23.8	14.7	13.8
December.....	106	195	180	313	167	14.8	5.9	8.6
Year.....	1,808	2,275	2,649	3,284	2,651	194.9	100.0	100.0

* Five years corresponding to those of barometric observations.

DAILY MARCH OF PRESSURE.

The equations for the daily pressure march of the individual months I have computed from the hourly pressure means for Alhajuela only; for the semidiurnal period, however, I have also deduced the constants of the daily march for the 12 months from the records at Ancon and Culebra. It will appear that Colon does not agree well with the other stations, its amplitudes are too small. In the equations $x=0$ for midnight (local time). The tables of bihourly means for Ancon, Culebra, and Colon are prepared for seventy-fifth meridian time (i. e., Washington time). Gen. Abbot's paper² made no mention of the time employed and at first I thought that "Washington time" was its standard also. But it is plain that local time was meant, otherwise the difference of the phase time A_2 , compared with other localities, would be too large and in general A_2 would become too great.

I find the following unreduced average annual values for A_2 :

Ancon, 153.5, or reduced to local time, 162.5.
Culebra, 147.3, or reduced to local time, 156.7.
Colon, 141.6, or reduced to local time, 151.4.

Probably the phase-angle for Colon is too small, for such great differences within such small distances can scarcely occur in the case of A_2 . The reduced values for Ancon and Culebra show a mutual difference of but 5.8° , i. e., about 12 minutes of time, which is permissible. The mean [of the three] is 159.6 and is in good agreement with the known phase-time of the tropical semidiurnal oscillation of pressure. But if Washington time is assumed, Alhajuela would give $A_2=175.9$, an altogether improbable high value. The unreduced value of $A_2=166.7$ is already a strikingly high one. Therefore, I assume that the observations at Alhajuela were made at local time.

The harmonic constants of the diurnal barometric march are given in the following table:

TABLE 5.—Constants of the harmonic analysis of the daily march of atmospheric pressure at Alhajuela, Canal Zone ($9^\circ 12' N.$, alt. 44 m.).

Month.	p_1	q_1	p_2	q_2	A_1	A_2	a_1	a_2
January.....	+0.56	+0.81	+0.11	-0.75	34.4	171.6	0.98	0.76
February.....	+0.56	+1.04	+0.24	-0.75	28.3	162.6	1.18	0.79
March.....	+0.56	+1.18	+0.34	-0.75	25.3	155.6	1.31	0.82
April.....	+0.44	+0.94	+0.30	-0.69	25.1	156.4	1.04	0.75
May.....	+0.38	+0.62	+0.14	-0.63	31.5	164.5	0.73	0.65
June.....	+0.52	+0.67	+0.11	-0.59	37.9	169.0	0.85	0.60
July.....	+0.49	+0.63	+0.23	-0.60	37.9	159.0	0.80	0.65
August.....	+0.55	+0.69	+0.14	-0.67	38.6	168.5	0.88	0.68
September.....	+0.54	+0.81	+0.13	-0.79	33.9	170.6	0.97	0.80
October.....	+0.49	+0.76	+0.12	-0.78	32.6	171.0	0.90	0.79
November.....	+0.48	+0.64	+0.08	-0.80	36.8	179.4	0.79	0.80
December.....	+0.54	+0.82	+0.12	-0.73	33.4	170.5	0.99	0.74
Year.....	+0.51	+0.80	+0.17	-0.75	32.4	166.7	0.95	0.73

$$p_1 \cos x + q_1 \sin x + p_2 \cos 2x, \quad \text{or} \quad a_1 \sin(A_1 + x) + a_2 \sin(A_2 + 2x).$$

I have computed the 8-hour period of the pressure for Alhajuela only. The regular annual period for the amplitude a_2 is not clearly expressed in 4- or 5-year means. I find the following equation for this annual period:

$$0.015 \sin(11.7^\circ + x) + 0.008 \sin(128^\circ + 2x).$$

It shows a maximum in May and a minimum in September. The seasonal means are, by direct averages,

Winter, 0.039 mm.; Spring, 0.041 mm.; Summer, 0.043 mm.; Autumn, 0.018 mm.; Year, 0.035 mm.

while according to the above equation the computed seasonal means would be

Winter, 0.037; Spring, 0.041; Summer, 0.032; Autumn, 0.013.

The annual march of these small magnitudes lies within their limits of error; and the annual mean agrees in amplitude and phase-time with the computed values for other localities.

The diurnal variation of atmospheric pressure naturally has its maximum amplitudes in the dry season—February to April—and its minimum amplitudes in July (not in the wettest month). The annual march of the amplitudes of the semidiurnal variation is of greater interest. The maxima at about the time of the equinoxes and the low minimum in June and July are specially characteristic. I have computed these amplitudes from a periodic series, and the resulting values are presented in Table 6.

TABLE 6.—Annual march of the amplitudes and phase-times of the diurnal barometric variation.

Month.	Alhajuella.				Ancon and Culebra.		
	a_1	a_2	A_1	A_2	a_3	A_3	
			(True time.)			Ap- proximate mean.	Re- duced to local and true time.
January.....	0.94	0.76	35.1	174.1	0.95	155.8	170.0
February.....	1.12	0.80	32.6	170.3	0.98	151.8	168.2
March.....	1.23	0.81	28.2	161.9	0.98	149.8	163.4
April.....	1.18	0.75	26.8	158.2	0.93	149.3	158.5
May.....	0.94	0.68	30.5	161.8	0.84	147.0	154.3
June.....	0.72	0.60	36.3	165.4	0.73	144.5	153.8
July.....	0.68	0.63	39.4	166.8	0.72	144.0	156.0
August.....	0.82	0.70	38.3	168.8	0.78	144.5	155.9
September.....	0.98	0.78	33.5	167.6	0.88	149.0	155.6
October.....	1.02	0.81	30.4	165.7	0.95	154.4	156.3
November.....	0.93	0.78	31.1	167.4	0.97	157.7	159.3
December.....	0.87	0.75	33.4	170.8	0.96	157.0	161.6
Year.....	0.95	0.735	33.0	166.6	0.89	150.6	159.7

AHAJUUELA.

$$a_1 = 0.15 \sin(58.8^\circ + x) + 0.17 \sin(305.2^\circ + 2x).$$

$$a_2 = 0.075 \sin(118^\circ + x) + 0.061 \sin(315.0^\circ + 2x).$$

ANCON and CULEBRA.

$$a_3 = 0.123 \sin(95.2^\circ + x) + 0.056 \sin(289.7^\circ + 2x).$$

In the following are given the equations for the daily barometric march at the extreme seasons, the dry season (February and March) and at the rainy season (October and November). Colon shows too small amplitudes and a divergent behavior during the wettest months, while the driest month shows the greater amplitudes.

Daily barometric march for the year, the driest and the wettest months.

Ancon (shore of the Pacific).

February and March, $0.78 \sin(10.3^\circ + x) + 0.90 \sin(152.5^\circ + 2x)$.
 October and November, $0.43 \sin(2.5^\circ + x) + 0.91 \sin(159.9^\circ + 2x)$.
 Year, $0.55 \sin(7.5^\circ + x) + 0.85 \sin(153.5^\circ + 2x)$.

Culebra (island on Pacific slope).

February and March, $0.98 \sin(16.6^\circ + x) + 1.04 \sin(148.1^\circ + 2x)$.
 October and November, $0.64 \sin(153^\circ + x) + 0.96 \sin(153.5^\circ + 2x)$.
 Year, $0.76 \sin(18.4^\circ + x) + 0.92 \sin(147.3^\circ + 2x)$.

Alhajuella (interior).

February and March, $1.24 \sin(26.8^\circ + x) + 0.80 \sin(159.1^\circ + 2x)$.
 October and November, $0.84 \sin(34.7^\circ + x) + 0.80 \sin(175.2^\circ + 2x)$.
 Year, $0.95 \sin(32.4^\circ + x) + 0.73 \sin(166.5^\circ + 2x) + 0.03 \sin(350.1^\circ + 3x)$.

Colon (shore of the Atlantic)⁵.

February and March, $0.55 \sin(1.3^\circ + x) + 0.67 \sin(137.7^\circ + 2x)$.
 October and November, $0.61 \sin(18.6^\circ + x) + 0.85 \sin(152.5^\circ + 2x)$.
 Year, $0.55 \sin(12.8^\circ + x) + 0.74 \sin(141.6^\circ + 2x)$.

The following rough differences between the daily marches for the dry and the wet seasons are of interest:

TABLE 7.—Differences between the daily march of atmospheric pressures in the dry season and the rainy season. (Dry—Rainy.)

	Mid- night.	2 ^a	4 ^a	6 ^a	8 ^a	10 ^a	Noon.	2 ^p	4 ^p	6 ^p	8 ^p	10 ^p
Ancon.....	22	40	38	20	7	1	0	-16	-29	-37	-28	-17
Culebra.....	17	27	28	25	10	13	3	-16	-41	-54	-21	3
Alhajuella.....	26	40	41	25	26	24	17	-14	-57	-60	-43	-15
Mean.....	22	36	32	23	14	13	7	-15	-42	-60	-31	-10

The pressure during the dry season is higher by night and lower by day than it is during the rainy season. This is also the well-known relation of the daily pressure march over ocean and coast as compared to that over inland stations. As is to be expected, this difference increases inland, as may be seen by comparing Ancon (coast) with Culebra and Alhajuella (inland). Colon on the Atlantic coast, behaves quite differently, as appears from Table 8:

TABLE 8.—Difference between the daily march of the atmospheric pressures in the dry season and the rainy season at Colon.

	Mid- night.	2 ^a	4 ^a	6 ^a	8 ^a	10 ^a	Noon.	2 ^p	4 ^p	6 ^p	8 ^p	10 ^p
Colon.....	-3	6	1	-12	-21	-8	36	50	28	-21	-36	-21

Here the differences have a semidiurnal period (double daily period). The maxima come at 2^h a. m. and 2^h p. m.; the minima come at 8^h a. m. and 8^h p. m. In the dry season the pressure is higher at 2^h p. m. than it is in the rainy season, lowest at 8^h p. m.; the afternoon minimum is weakened, as also the evening maximum. The forenoon extremes are also less pronounced. At Colon it is evident that it is not so much the rainy season as the prevailing winds that have the greatest influence on the daily march of the barometer. At Colon the sea winds—the north and northeast trades—blow exclusively during the dry season; during the rainy season the winds are more land winds from the south and southwest. On the other side of the divide, at Culebra and Ancon, the north and northeast winds are land winds and the southerly winds are sea winds. Evidently, the strong and very dominant sea or trade wind at Colon in winter

⁵ The following check computation for Colon was made from the original figures (English inches):

January—March, $0.63 \sin(14.3^\circ + x) + 0.74 \sin(139.8^\circ + 2x)$.
 April—June, $0.82 \sin(21.8^\circ + x) + 0.64 \sin(146.3^\circ + 2x)$.
 July—September, $0.72 \sin(18.4^\circ + x) + 0.64 \sin(146.2^\circ + 2x)$.
 September—December, $0.38 \sin(34.4^\circ + x) + 0.76 \sin(152.1^\circ + 2x)$.
 Year, $0.63 \sin(21.4^\circ + x) + 0.69 \sin(146.4^\circ + 2x)$.

Here, as above, the amplitudes of the semidiurnal periods are certainly too small, and the same is true for the phase-angles of the semidiurnal periods at any rate near the beginning of the year.

is the wind that there outweighs the rainy season in influencing the daily barometric march. At Colon, in the dry season, 97 per cent of the winds are from the Atlantic Ocean, while in the rainy season these are but 22 per cent, and there are 50 per cent from the south, i. e., from the land. Hence the divergence. It is scarcely to be assumed that the small amplitude a_2 (only 0.67 mm.) is due to this circumstance. I regard this small value as improbable.

Finally, the intermediate (mean) ordinates of the daily barometric curve should be mentioned. Here, again, Colon probably has too small amplitudes, while for Alhajuela they probably are too large. But in this case we have 24 hourly observations, while the other three localities have but bihourly observations, whereby the daily march is somewhat flattened. (See Table 9.)

TABLE 9.—Average ordinates of the curves of the daily march of pressure (maximum).

	Ancon.	Culebra.	Alhajuela.	Colon.	Means.
January.....	0.659	0.752	0.748	0.527	0.671
February.....	0.650	0.777	0.885	0.539	0.713
March.....	0.639	0.821	0.967	0.547	0.756
April.....	0.673	0.780	0.772	0.545	0.693
May.....	0.544	0.597	0.677	0.508	0.557
June.....	0.479	0.624	0.639	0.452	0.548
July.....	0.449	0.663	0.621	0.437	0.517
August.....	0.547	0.617	0.677	0.498	0.585
September.....	0.609	0.648	0.754	0.582	0.648
October.....	0.644	0.638	0.730	0.602	0.651
November.....	0.652	0.687	0.663	0.533	0.646
December.....	0.626	0.727	0.748	0.618	0.680
Year.....	0.595	0.675	0.724	0.518	0.639

DAILY MARCH OF TEMPERATURE AND RELATIVE HUMIDITY.

I have computed the equations for the daily march of the temperature and the relative humidity for the extreme seasons, for the dry season, the rainy season, and for the year. In the following table these equations are grouped together. (See Tables 10, 11, and 12.)

Daily march of temperature.—In Ancon, Culebra, Colon, and Alhajuela * the temperature maximum occurs later in the dry season than it does in the rainy season, and the amplitudes are almost twice as great in the dry season as they are in the rainy season. Colon, however, is an exception to the latter rule, as its daily temperature range during its rainy season (October–November) is greater than during its dry season. The reason for this condition is to be sought in the wind conditions, which we have described above. The dry season has strong northerly sea winds (the trades), while the rainy season has southerly land winds. In Colon also, however, the rainy season has a lower average temperature than the dry season.

* Hann, Julius. Der tägliche Gang der Temperatur in den Tropen. I.—Das innere Tropengebiet. Denkschr., Kaiserl. Akad. d. Wissensch., Wien, Mathem.-naturw. Kl., 1905, 78: 284, 337.

TABLE 10.—Daily march of temperature and humidity.

ANCON (lat., 8° 57' N.; long., 79° 33' W.; alt., 28 m.)
(Departures from daily mean.)

Hours.	Dry season.		Rainy season.		Year.	
	Temperature.	Relative humidity.	Temperature.	Relative humidity.	Temperature.	Relative humidity.
	° C.	Per cent.	° C.	Per cent.	° C.	Per cent.
Midnight.....	-3.3	13	-1.8	7	-2.4	9.3
2 a.....	-3.6	16	-2.2	7	-2.8	10.4
4 a.....	-4.1	17	-2.4	8	-3.2	10.8
6 a.....	-4.5	17	-2.8	7	-3.4	11.1
8 a.....	-1.3	13	-0.1	5	-0.7	7.9
10 a.....	3.0	3	2.8	5	2.7	3.8
Noon.....	5.2	-19	3.9	-13	4.3	-14.9
2 p.....	5.7	-23	3.1	-14	4.2	-17.0
4 p.....	4.9	-23	1.8	-10	3.0	-14.7
6 p.....	1.6	-17	0.2	-4	0.9	-8.6
8 p.....	-1.3	-4	-0.8	3	-1.0	0.3
10 p.....	-2.5	9	-1.4	6	-1.9	7.1
Mean.....	3.4	14	1.9	7	2.5	9.7
Amplitude.....	9.9	40	6.7	21	7.7	28.1

EQUATIONS OF THE DIURNAL CURVES.

Dry season.

Temperature, $26.2+5.02 \sin (238.8^\circ+x)+1.33 \sin (57.3^\circ+2x)$.
Relative humidity, $73.5+20.6 \sin (42.1^\circ+x)+5.2 \sin (205.9^\circ+2x)$.

Rainy season.

Temperature, $25.0+2.76 \sin (242.6^\circ+x)+1.10 \sin (91.6^\circ+2x)$.
Relative humidity, $87.5+10.7 \sin (59.4^\circ+x)+3.7 \sin (231.2^\circ+2x)$.

Year.

Temperature, $25.8+3.77 \sin (242.0^\circ+x)+1.10 \sin (76.2^\circ+2x)$.
Relative humidity, $82.0+14.5 \sin (49.5^\circ+x)+3.8 \sin (233.6^\circ+2x)$.

TABLE 11.—Daily march of temperature and humidity.

CULEBRA (lat., 9° 3' N.; long., 79° 39' W.; alt., 123 m.)
(Departures from daily mean.)

Hours.	Dry season.		Rainy season.		Year.	
	Temperature.	Relative humidity.	Temperature.	Relative humidity.	Temperature.	Relative humidity.
	° C.	Per cent.	° C.	Per cent.	° C.	Per cent.
Midnight.....	-2.7	14	-1.5	6	-1.9	9.4
2 a.....	-3.1	15	-1.8	7	-2.3	10.3
4 a.....	-3.5	17	-2.0	7	-2.6	10.7
6 a.....	-3.8	17	-2.2	7	-2.8	11.0
8 a.....	-1.4	13	-0.5	5	-1.0	8.7
10 a.....	2.6	2	2.3	3	2.5	2.5
Noon.....	4.4	-18	3.6	-13	4.0	-15.2
2 p.....	4.9	-23	2.7	-14	3.5	-18.0
4 p.....	3.7	-22	1.3	-8	2.4	-14.1
6 p.....	1.4	-17	0.1	-2	0.7	-7.9
8 p.....	-1.0	-1	-0.9	3	-0.9	1.2
10 p.....	-2.0	10	-1.1	6	-1.5	7.3
Mean.....	2.9	14	1.7	7	2.2	9.7
Amplitude.....	8.7	40	5.8	21	6.8	29.0

EQUATIONS OF THE DIURNAL CURVES.

Dry season.

Temperature, $25.0+4.71 \sin (229.8^\circ+x)+1.15 \sin (62.4^\circ+2x)$.
Relative humidity, $76.0+13.0 \sin (59.5^\circ+x)+4.9 \sin (194.7^\circ+2x)$.

Rainy season.

Temperature, $24.4+2.50 \sin (247.4^\circ+x)+1.12 \sin (93.6^\circ+2x)$.
Relative humidity, $89.3+9.1 \sin (70.8^\circ+x)+4.0 \sin (226.8^\circ+2x)$.

Year.

Temperature, $24.0+3.18 \sin (242.5^\circ+x)+1.10 \sin (75.2^\circ+2x)$.
Relative humidity, $84.0+14.4 \sin (49.5^\circ+x)+4.4 \sin (211.4^\circ+2x)$.